ATF Experimental Program and ATF2 Construction Status

T. Tauchi,

Nanobeam 2008, BINP, Novosibirsk, 26-30 May 2008

References :

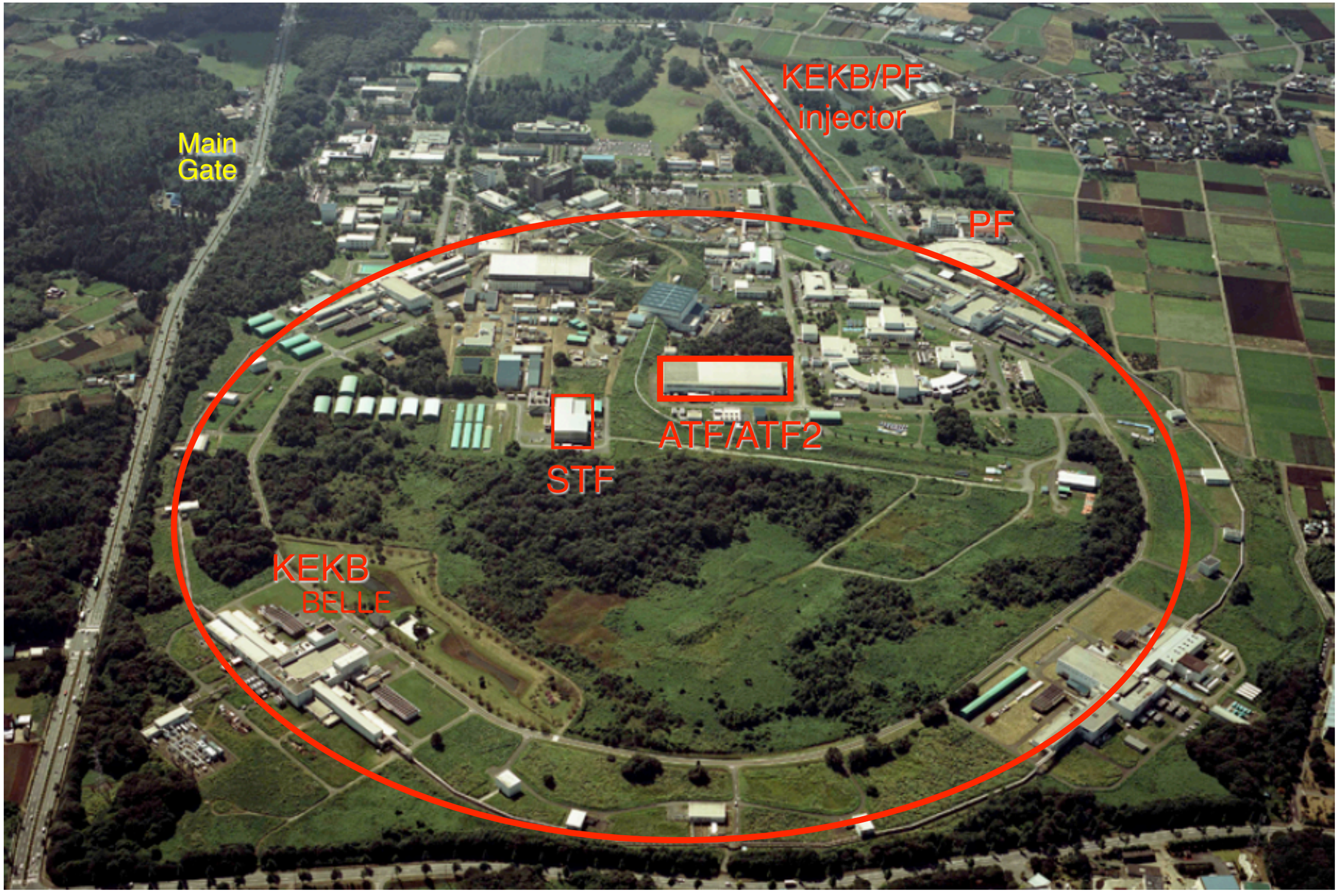
ATF2 Proposal, KEK Report 2005-2

ATF2 Proposal Vol.2, KEK Report 2005-9

Home page : http://atf.kek.jp/collab/ap/projects/ATF2/index.php

KEK High Energy Accelrator Research Organization

in Tsukuba site, Japan



ATF Accelerator Test Facility, KEK

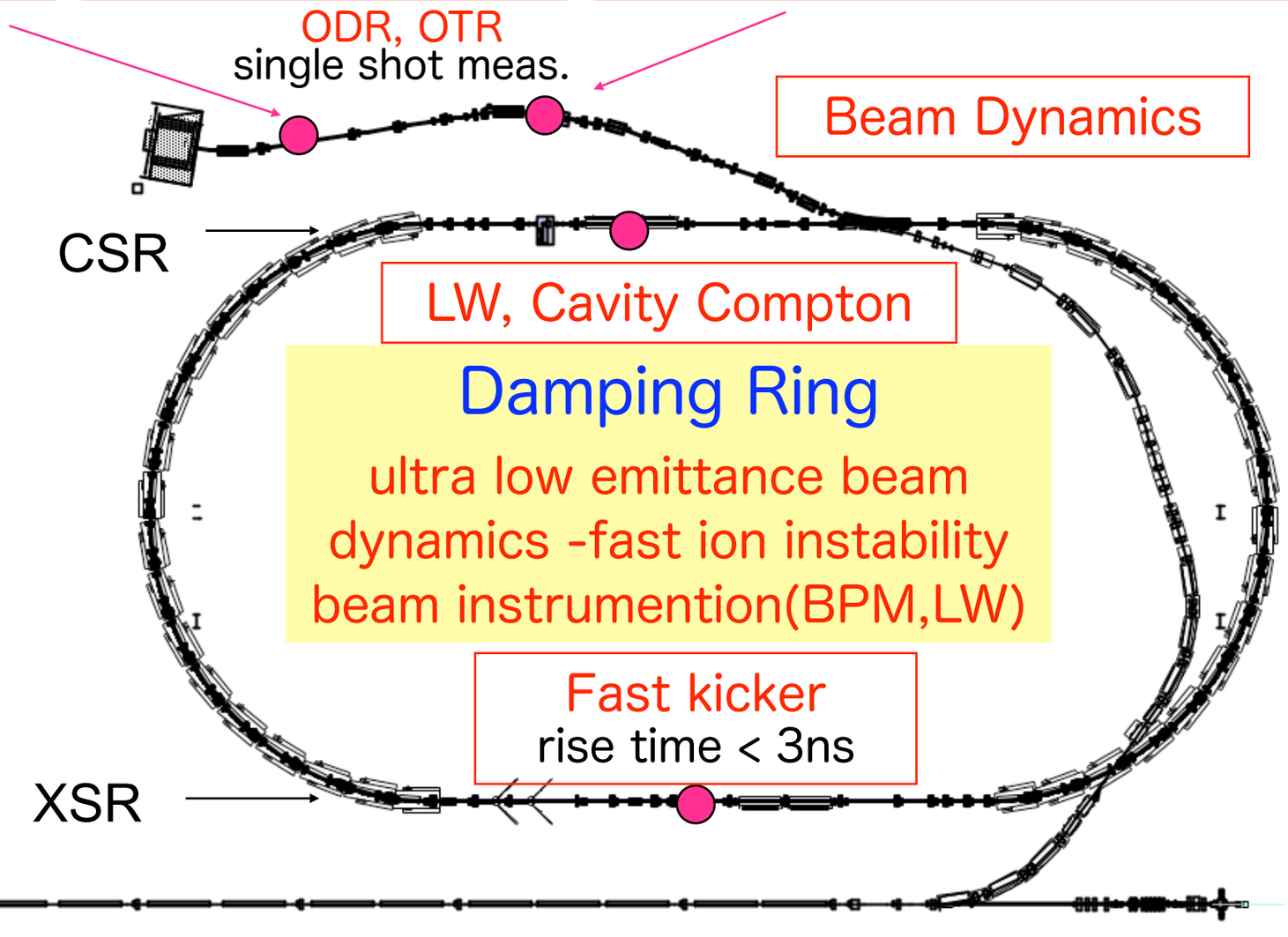
1997-2008

Extraction line :utilization of low emittance beam
beam instrmentation, collimator damage

Cavity BPM
nanometer res.

FONT
fast feedback (ns)

Pulsed Laser Wire Scanner
for beam size monitor (μm)



Energy: 1.28 GeV
Electron bunch:
$2x10^{10}$ e/bunch
1 ~ 20 bunches/train
3 trains/ring
1.56 Hz

RF Gun
multi-bunch beam

S-band Linac (70m)
multi-bunch acceleration

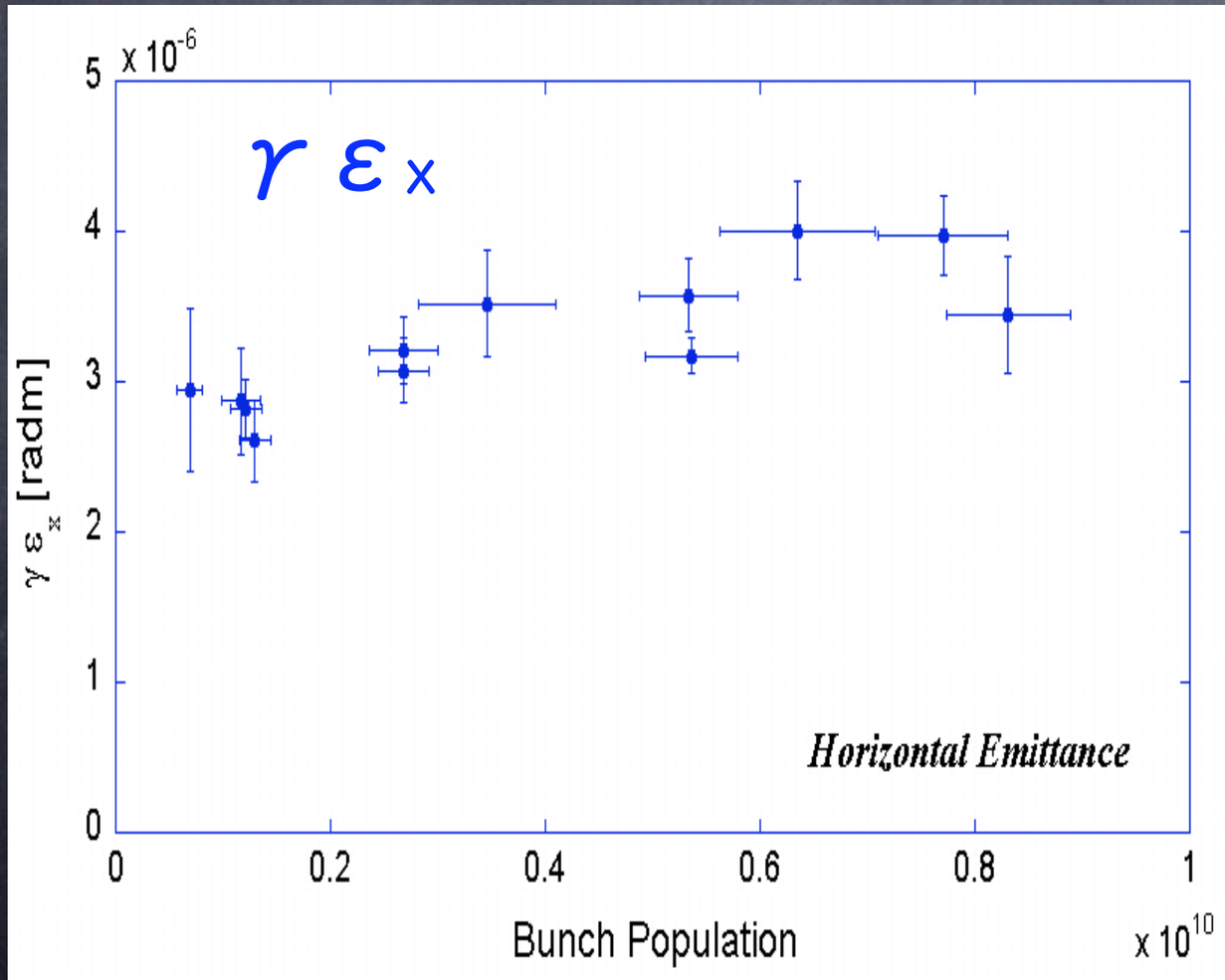
The Primary Goal is Generation of Ultra Low Emittance Beam with Energy of 1.3 GeV

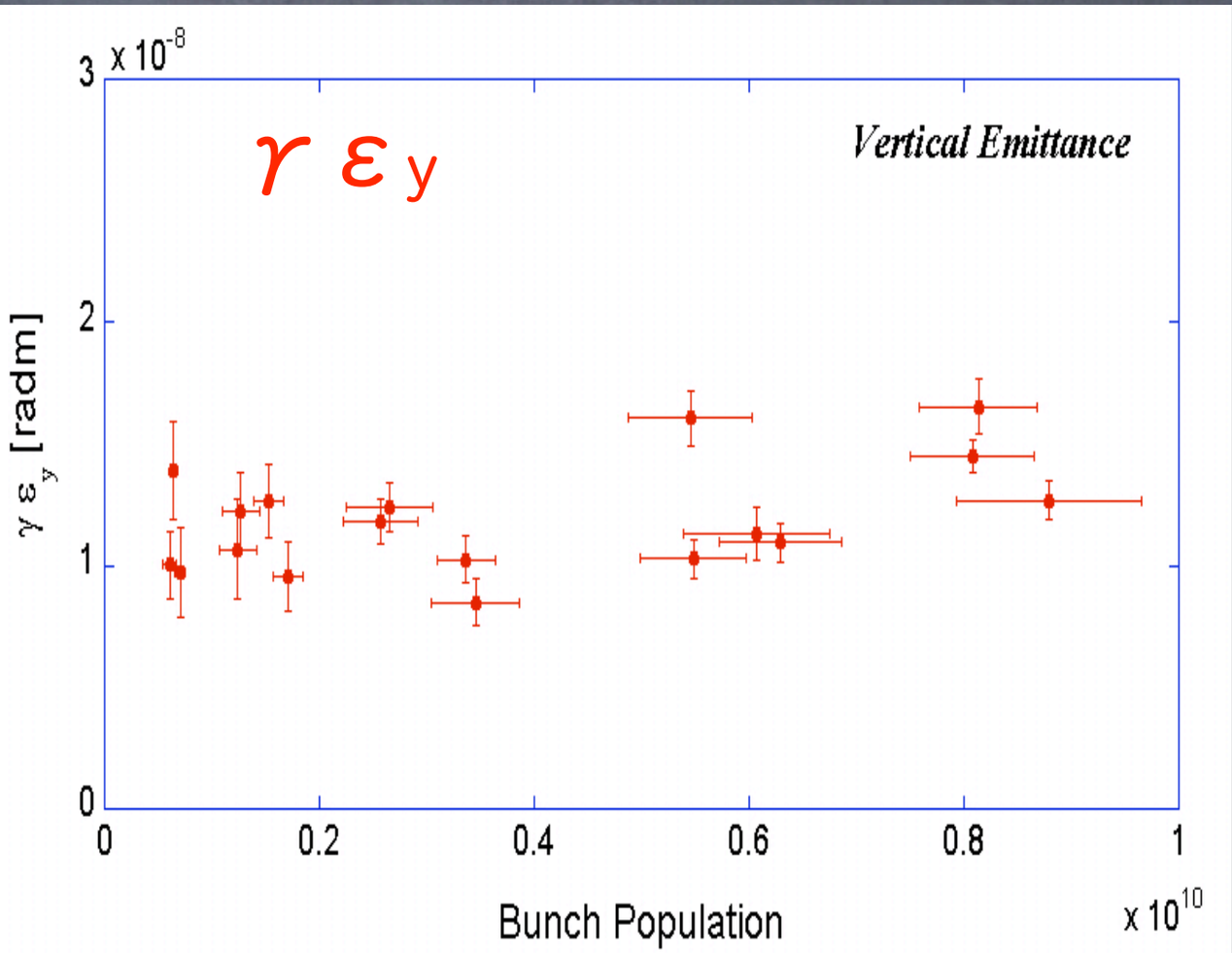
Commissioning,1997, Achievement of the emittance, 2001

K.Kubo et al.,PRL88 (2002)194801

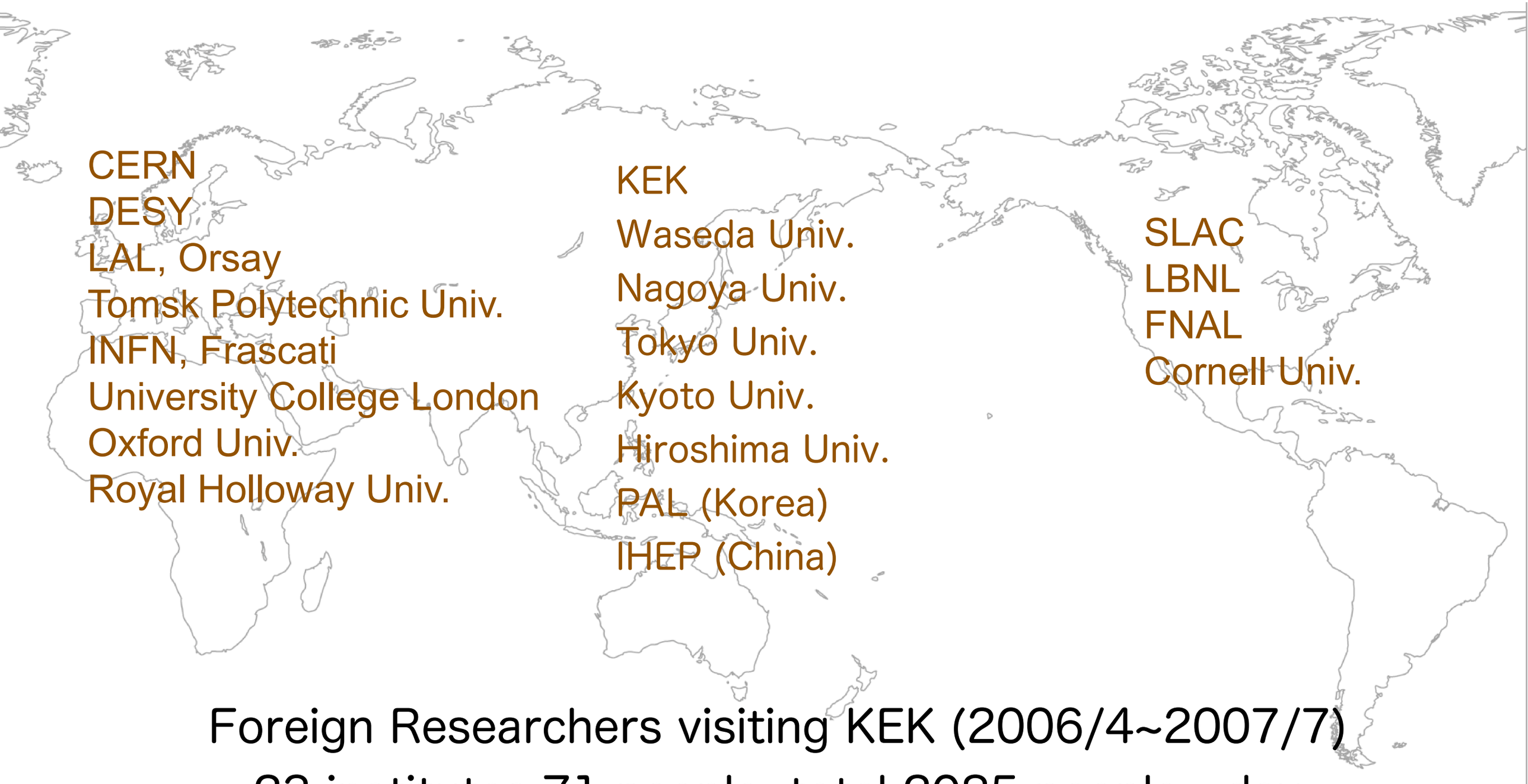
ε_x=1.5nm and ε_y=4pm , 2003

Y.Honda et al.,PRL92 (2004)054802





ATF International Collaboration



Foreign Researchers visiting KEK (2006/4~2007/7)

23 institutes,71 people, total 2085 people・day

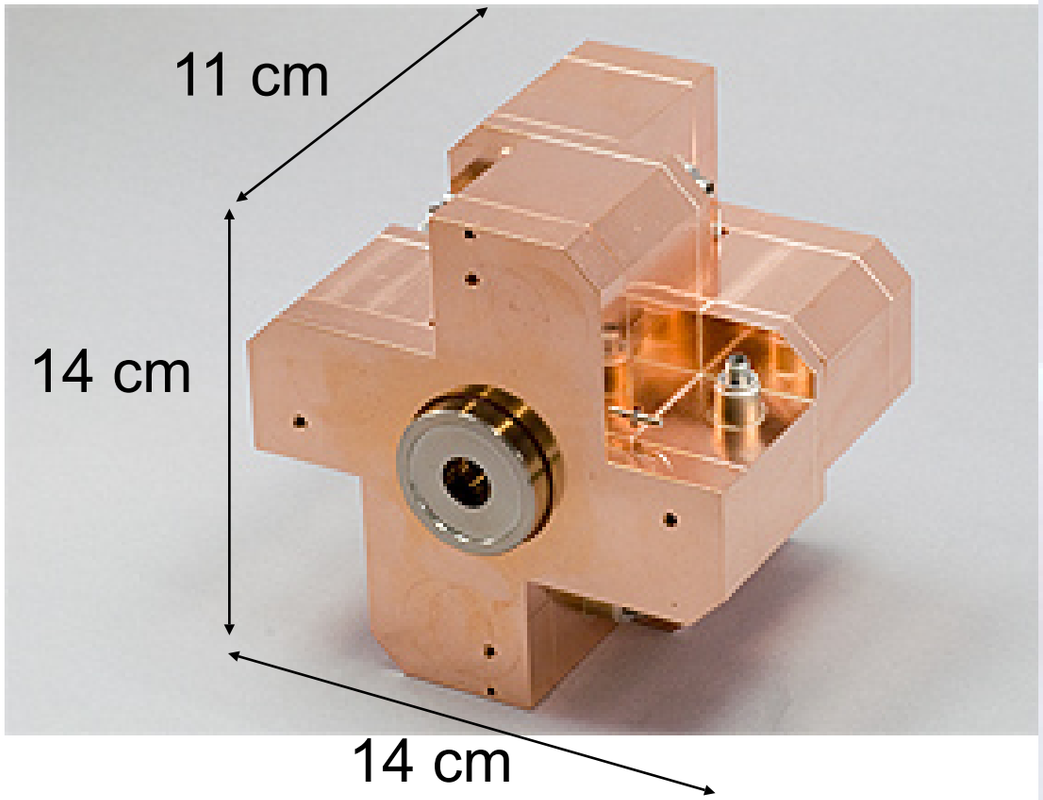
(full-year researchers are excluded)

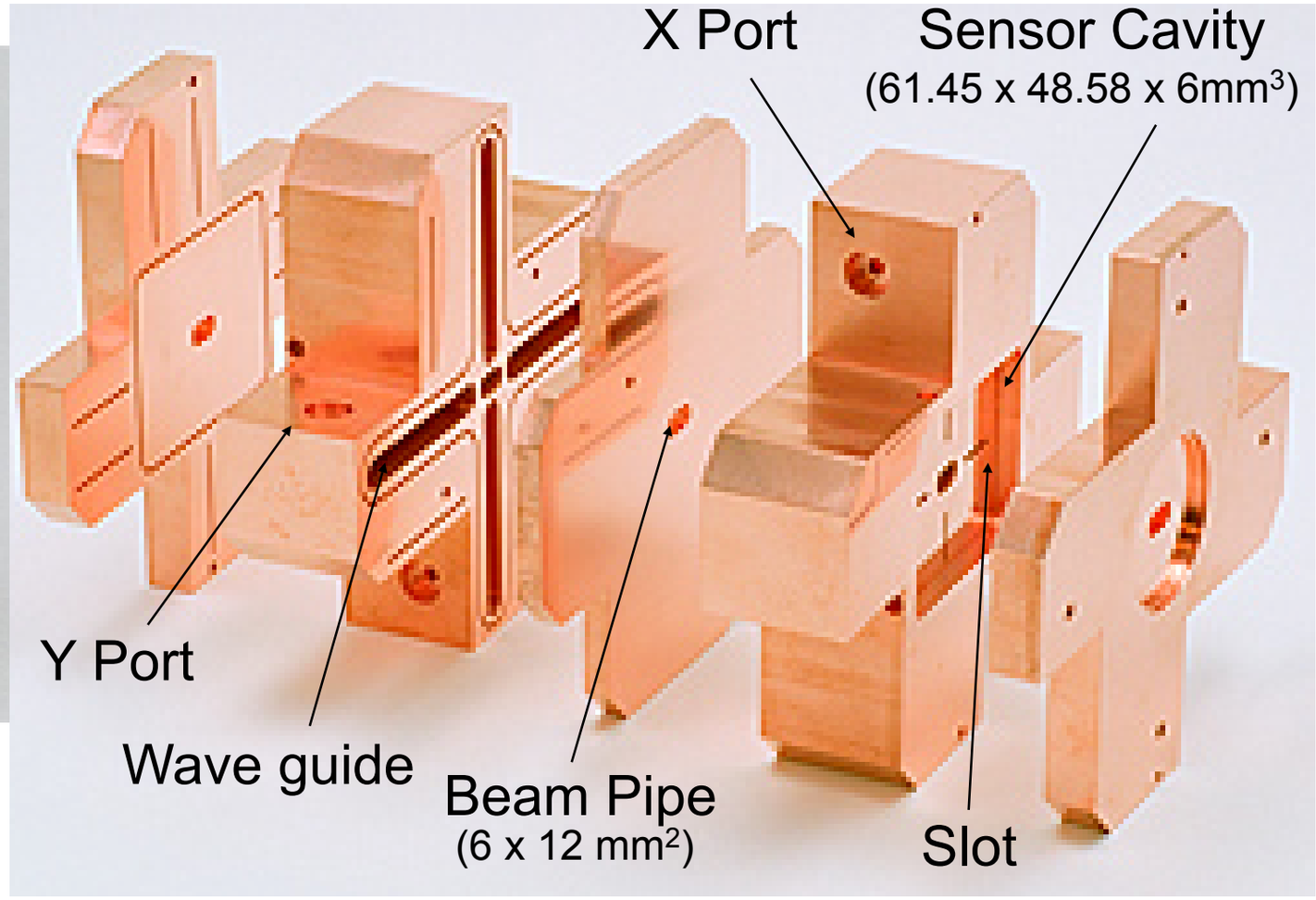
(KEK, KNU)

IP-BPM

Goal : 2nm position resolution

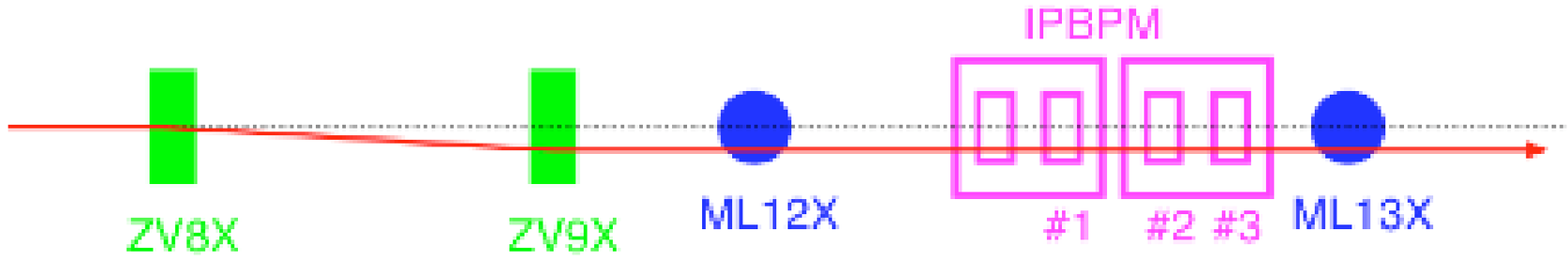
Rectangular cavity for X-Y isolation (-50dB)
- **2 Cavities in 1 block**
- **2 Y ports and 2 X ports in 1 Cavity**





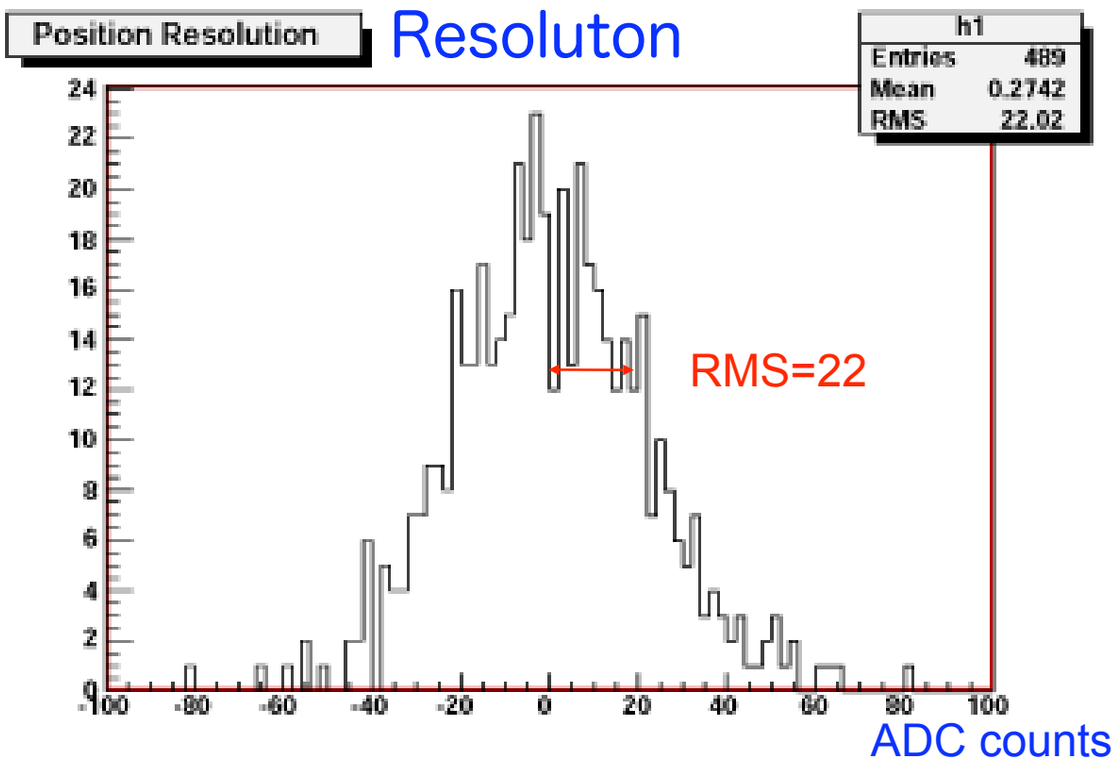
IPBPM : resoulution and stability

Test Setup



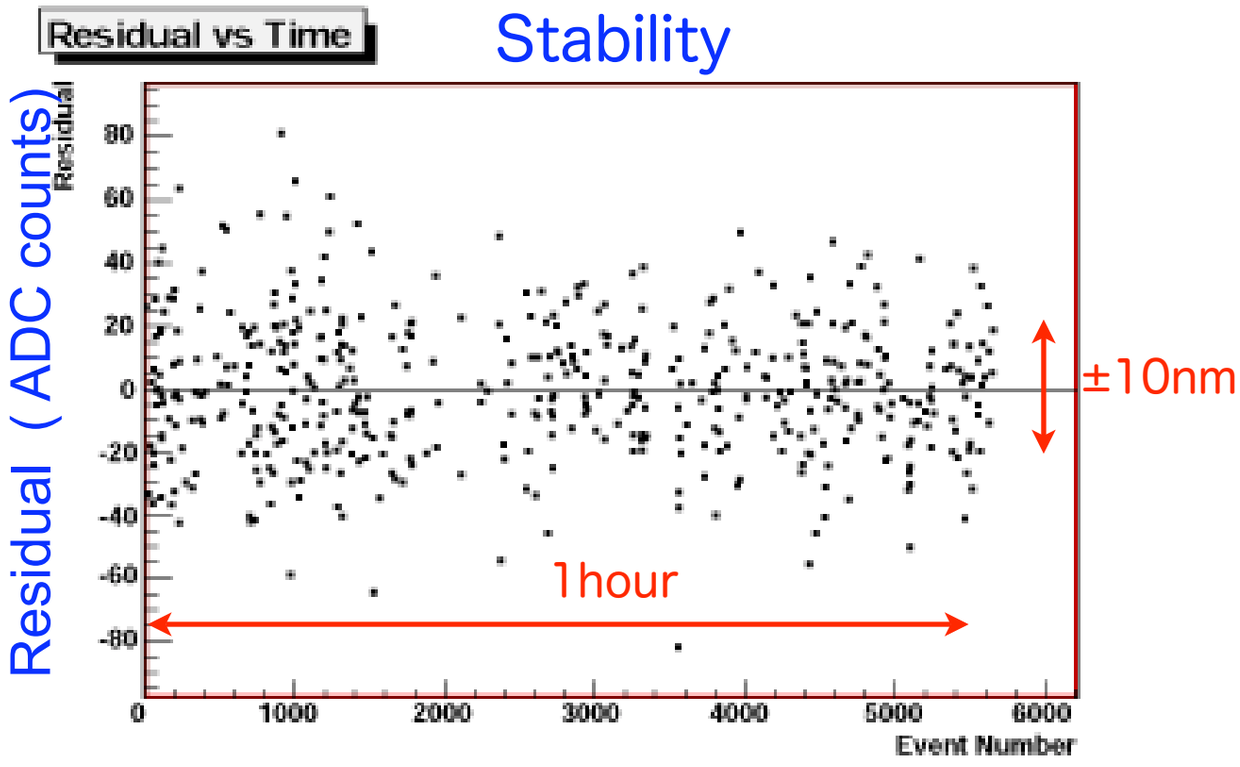
Calibration : 2 ADC counts/nm

Resoluton



Residual of (Y2I – $Y2I_{predicted}$)

Stability



Time (event number, 1.5Hz)

condition : beam intensity =0.7x10^{10}/bunch, dynamic range = 5μm

Resolution(1 hour) = 8.7±0.3(stat.)±0.4(sys.) nm

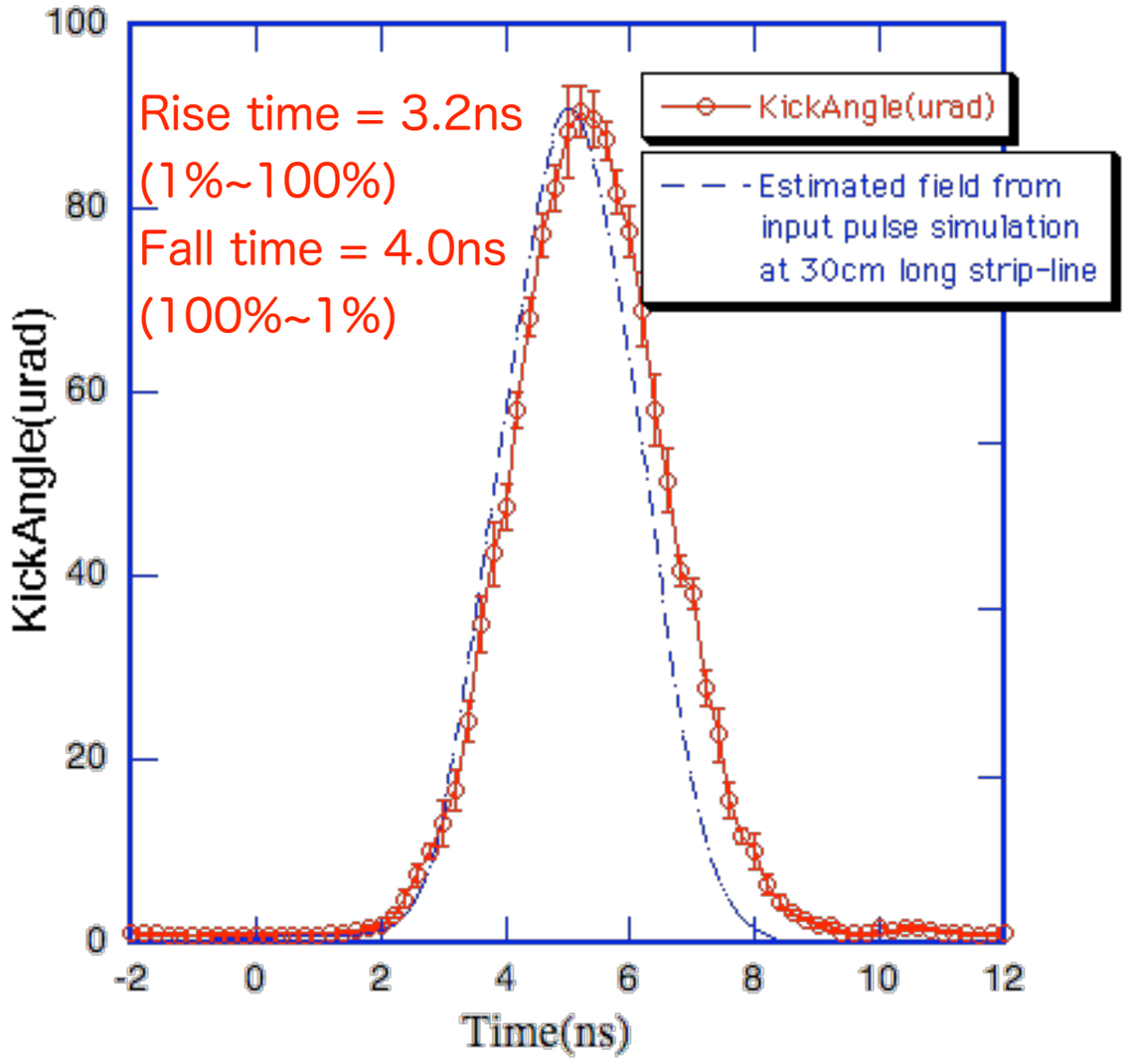
2nm-goal : 1x10^{10}/bunch, temperture, signal intesity, active support ..

Fast kicker

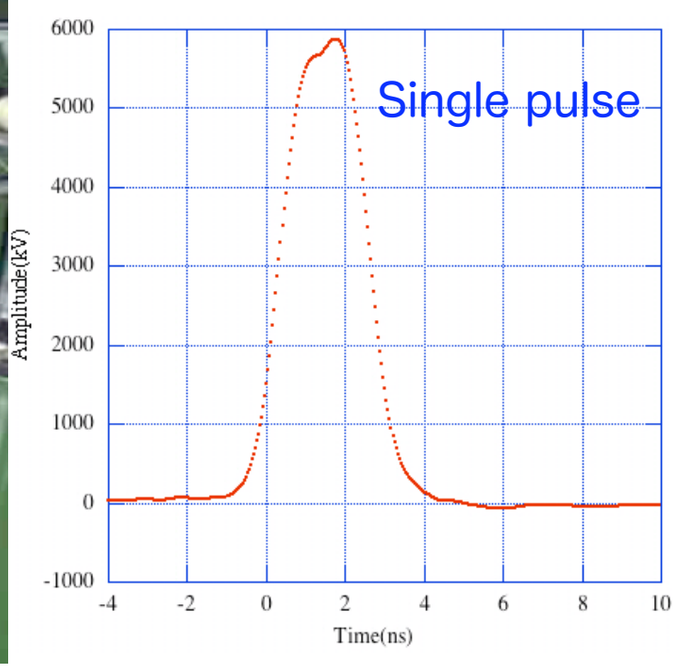
(ILC specification)

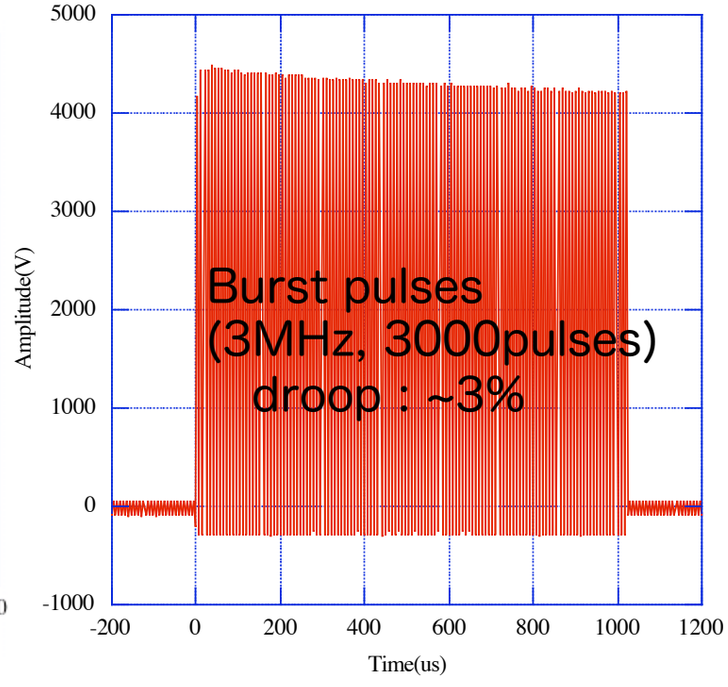
(KEK,LLNL,SLAC,LNF,DESY, FID Co.)

Measured Results by beam kick, 2007



FID FPG-3000M (3MHz, 3000 pulses)



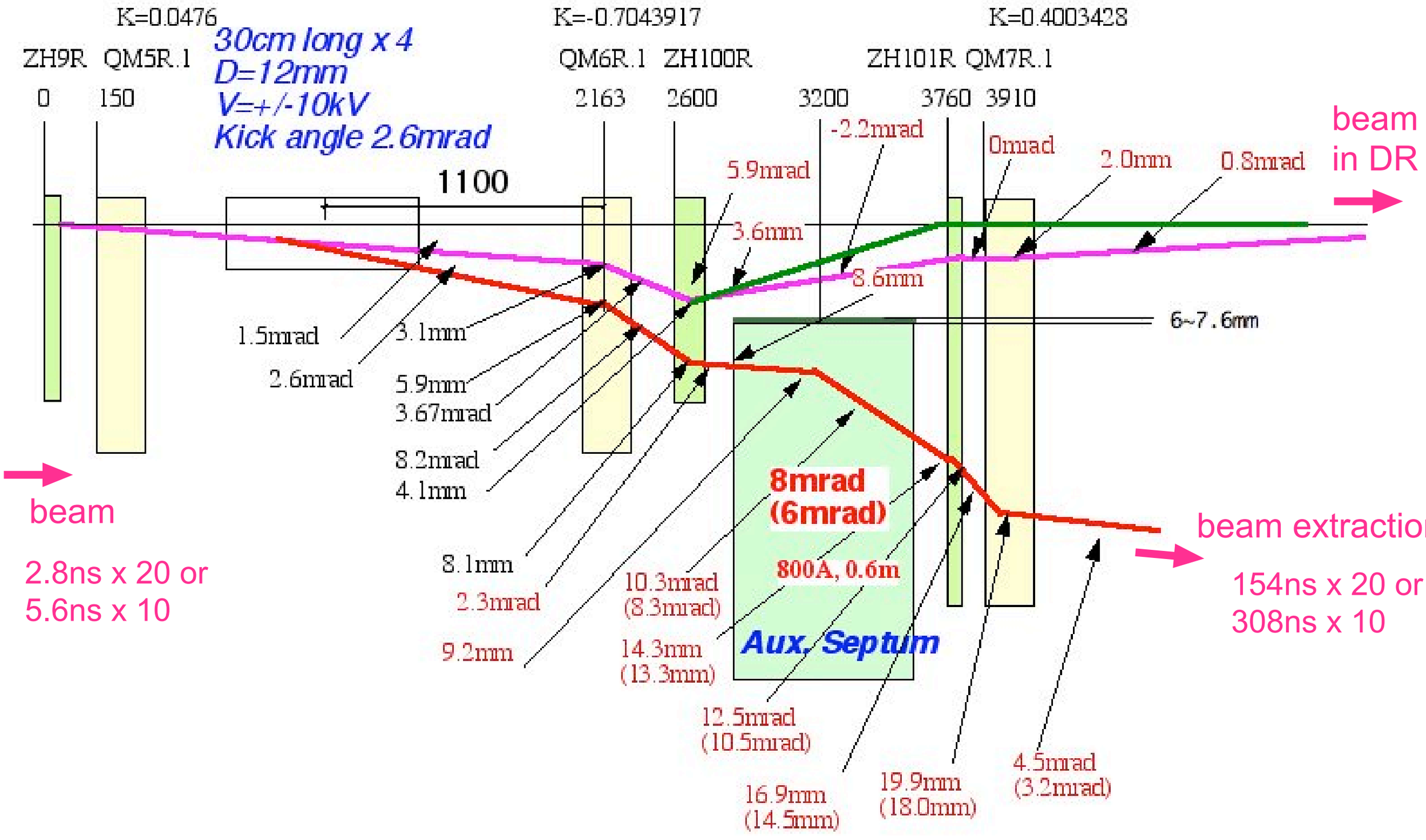


Beam extraction orbit by using Strip-line Kicker

Generation of “ILC beam”

Plan by T.Naito, May 2008

2.6mrad kick angle



ATF2 Proposal Vol.1 and 2
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(University of Tokyo, Tokyo)

5th ATF2 Project Meeting, 19-21 Dec. 2007

ATF2 beam line

Final Focus System

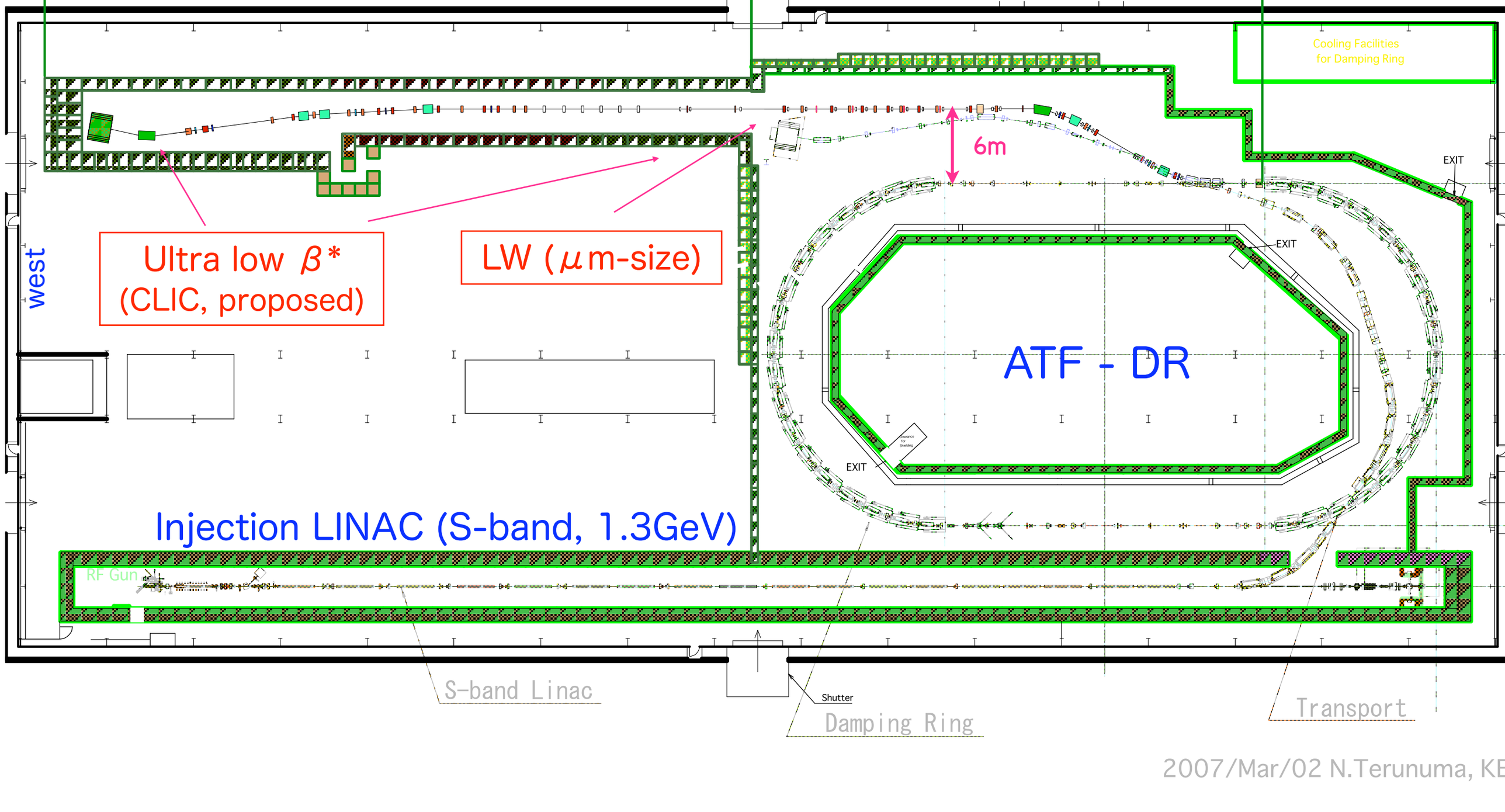
57000

β mat-ching

Diagnostic

Reconfiguration of extraction line for reduction of dispersion

41179.42



2007/Mar/02 N.Terunuma, KE

ATF2 Final Goal

Ensure collisions between nanometer beams; i.e. luminosity for ILC experiment

Reduction of Risk at ILC

Optics and bean tuning
Stabilization

FACILITY construction, first result	ATF2/KEK; 1.3GeV 2005-08-09?	FFTB/SLAC; 47GeV 1991-93-94
Optics	Local chromaticity correction scheme; very short and longer L* (β^*_y=100μm, L_{FF}=30m)	Conventional (separate) scheme; non-local and dedicated CCS at upstream; high symmetry in x, y ; i.e. orthogonal tuning (β^*_y=100μm, L_{FF}=185m)
Design beam size	2.3μm / 34nm, aspect=82 ($\gamma\varepsilon_y$=3 x 10^{-8} m)	1.92μm /52nm, aspect=37 ($\gamma\varepsilon_y$=2 x 10^{-6} m)
Achieved	?	70nm (beam jitter remains !)

Mode-I

A. Achievement of 34nm beam size

A1) Demonstration of a new compact final focus system;
proposed by P.Raimondi and A.Seryi in 2000,

A2) Maintenance of the small beam size
(several hours at the FFTB/SLAC)

Mode-II

B. Control of the beam position

B1) Demonstration of beam orbit stabilization with
nano-meter precision at IP.
(The beam jitter at FFTB/SLAC was about 40nm.)

B2) Establishment of beam jitter controlling technique
at nano-meter level with ILC-like beam (2008 -?)

ILC-FF (660m)

electron beam

$\sqrt{\beta_x}, \sqrt{\beta_y}\ (\sqrt{\mathrm{m}})$

$\eta_x, \eta_y\ (\mathrm{m})$

SD0 SF1 B1 B2 SD4 SF5 B5 SF6 QM11 QM16

ATF2-FF (30m)

electron beam

IP

F

D

m

ATF2 Features

- The same number of magnets as the ILC-FF.
- The tuning knob, methods are the same,too.
- Beam instrumentation has been developed with the ILC specifications; BPMs, BSMs, movers, magnet support, laserwires, HA power supplies, FONT-feedback system etc. .
- International participation in the commissioning and operation

Future prospects

ILC beam; 30(60) bunches s_b=300(150)nsec

- Fast extraction kicker R&D in 2007-
- intra-pulse feedback (FONT, Oxford university)

Final focus Q magnet test ; 2012 - 2014

- super conductiong magnet (BNL)
- permanent magnet (Kyoto university)

Optional Photon facility ; 2015 - 2019

- laser and optical cavities for photon linear collider
- generation of photon beam

"Strong QED" experiments ; LEI2007, Hiroshima

- Non-perturvative QED with Laser intensity 10^{22}W/cm^2

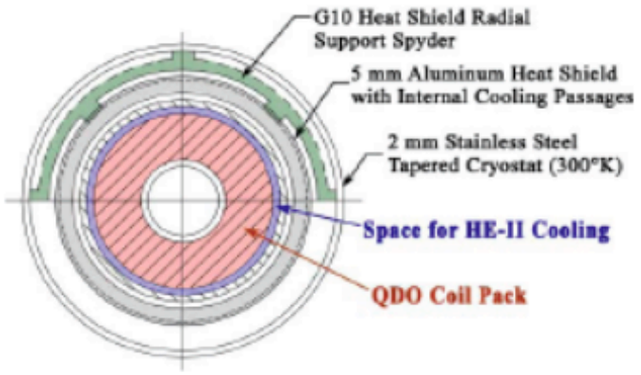
i.e. $a_0 > 60$, $A > 3 \times 10^{25}$m/s^2 , E_{laser}>2TeV/cm

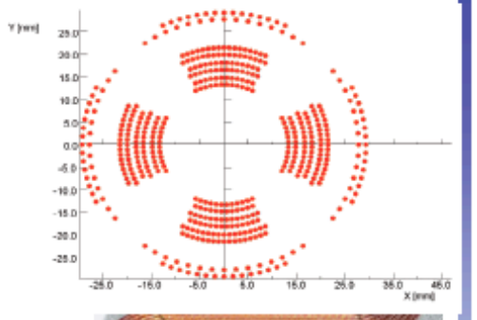
Compact QD0 : superconducting magnets R < 3cm

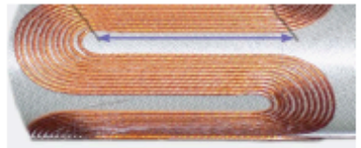
14mr crossing and L*= 3.5 - 4.5m

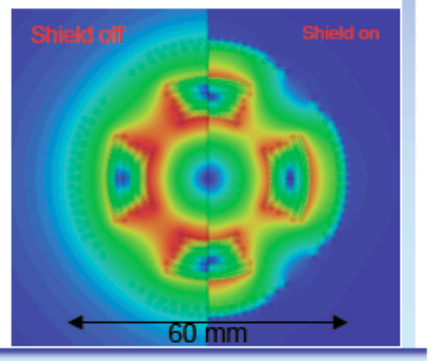
Base line design (RDR)

BNL design





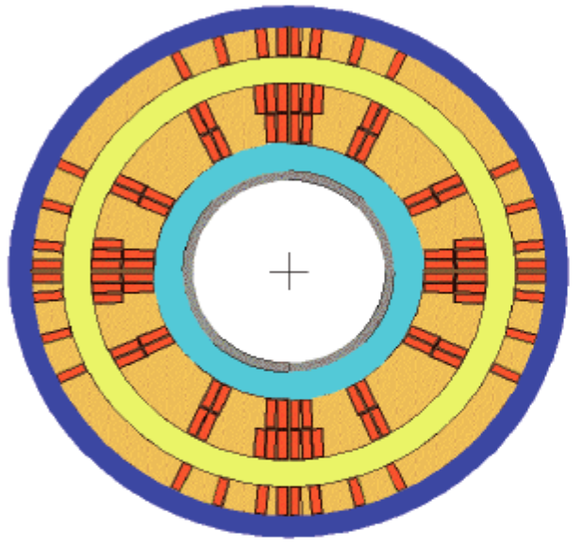




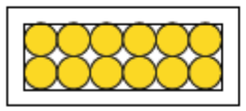
- Well advanced design based on the direct wind technology (BNL)

Issues:
- Works for NbTi strand
- Need inner support tube
- Limited radial and azimuthal thermal conductivity

FNAL concept



- Use Rutherford cable
  - Self-supported Roman arch
  - Smaller number of turns
  - Better turn position control
  - Low inductance
  - Better radial thermal conductivity
- Thermally decouple beam pipe and coil
- Active shield
- Same beam pipe size
- Smaller coil OD

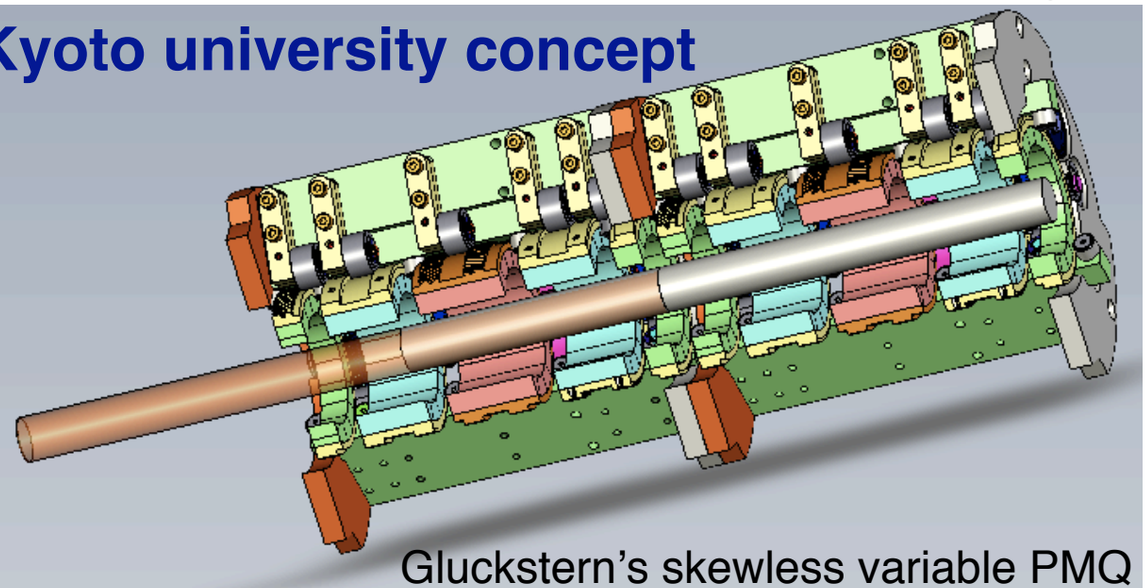


Cable:
N=12, D=0.5 mm
1 x 3 mm

Compact QD0 : permanent magnets

Iwashita's talk at this workshop

Kyoto university concept



Gluckstern's skewless variable PMQ

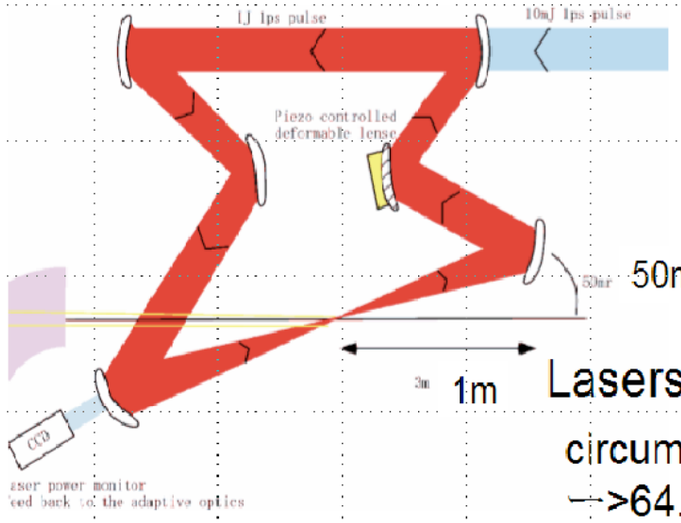
Comment on cryogenics system

"We may use a stand alone cryogenics system which is commercially available" (J. Urakawa, SLAC-KEK ATF2 collaboration meeting, 26-30 March 2008), which must be important to realize at ATF2.

An example of commercial products is a single stage GM/JT cryocoolers by SHI Cryogenics Group. These equipments have been developed for application to MRI. So, they are very compact and easy operation. However, the temperature is 4.3K and the power is 4.2W per a cryocooler. Another issue is stability, i.e. vibration. This system has no transfer tube for liquid He, but the cryocooler is mount on the cryostat of QD0 .

Takahashi's talk at this workshop

Photon Collider test bed and other possibilities at future ATF2



For 154ns spacing:
1/10 scale (15.4ns)

A laser pulse hits once in 10 turns

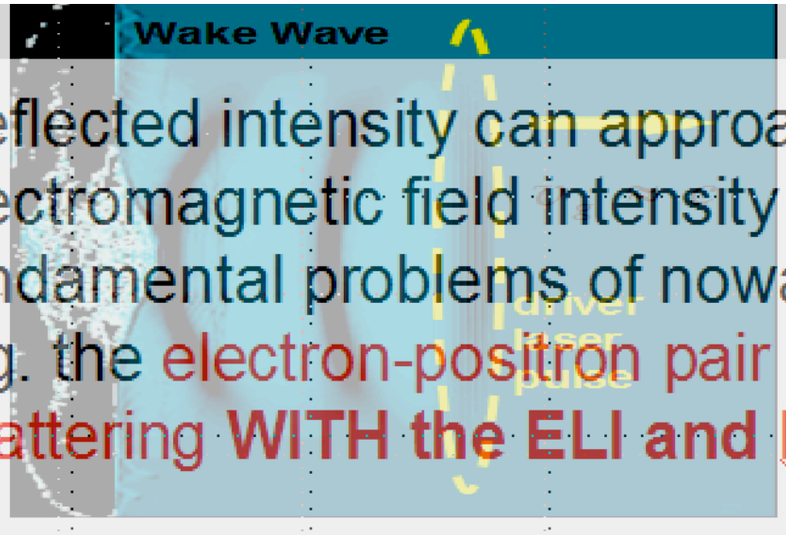
circumference 4.62m (15.4ns)
→>64.9MHz

very similar to PosiPol experiment → 10W mode locked,,,154nJ/pulse
->15.4μJ/pulse w/ 100 pulse stacking
2400γ/xing

T.Takahashi Hiroshima

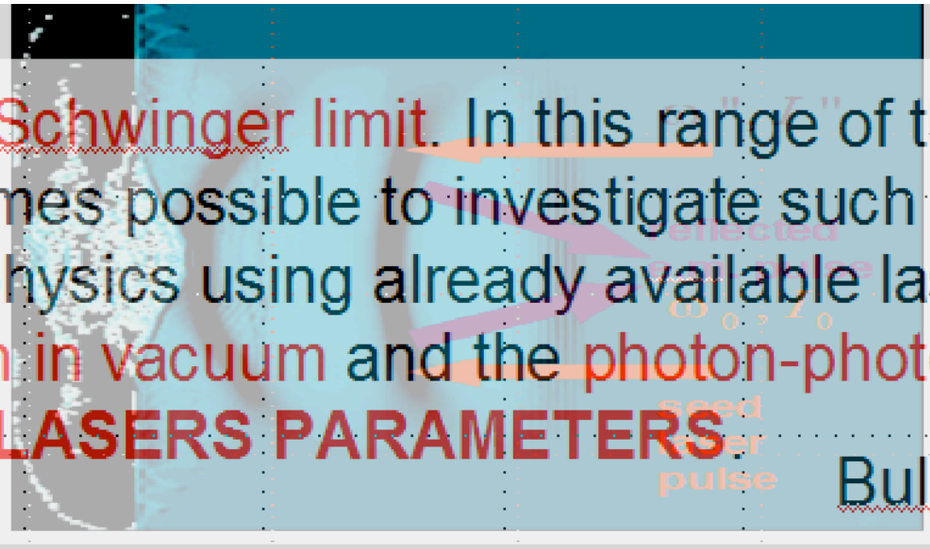
- ATF2 can be
  - **place for he PLC test bed**
    - demonstration of high intense photon beam
- ATF2 beam + intense field
  - **possibly place to perform another aspect of particle physics**

Smaller for DR or full size for ILC bunch spacing



Reflected intensity can approach the Schwinger limit. In this range of the electromagnetic field intensity it becomes possible to investigate such the fundamental problems of nowadays physics using already available laser, as e.g. the electron-positron pair creation in vacuum and the photon-photon scattering **WITH the ELI and HiPER LASERS PARAMETERS**.

Bulanov



$$\omega'' = \frac{1 + v_{ph}/c}{1 - v_{ph}/c}\omega \approx 4\gamma_{ph}^2\omega_0$$

$$I''_{\max} \approx \kappa(\gamma_{ph})\,\gamma_{ph}^6 \left(\frac{D}{\lambda}\right)^2 I_0$$

$$\kappa(\gamma_{ph}) \sim \gamma_{ph}^{-3}$$

Magnets and Instrumentation at ATF2

22 Quadrupoles(Q), 5 Sextupoles(S), 3 Bends(B) in downstream of QM16

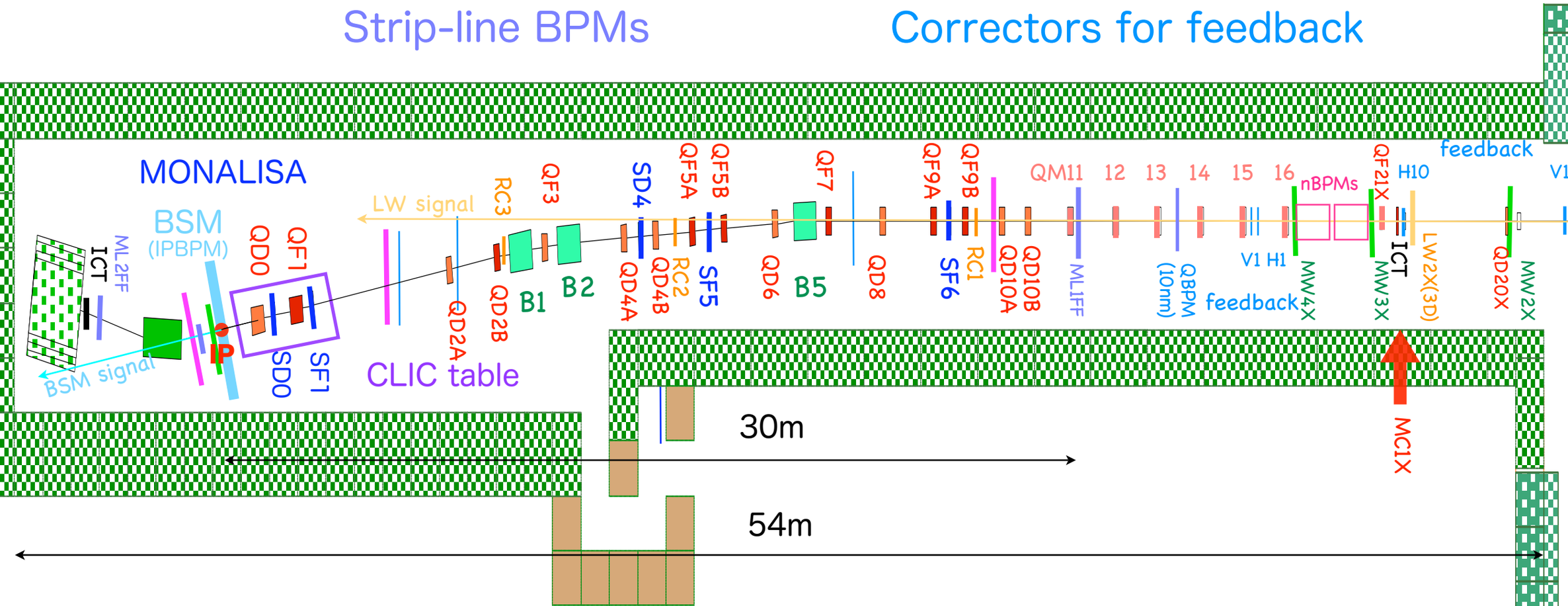
All Q- and S-magnets have cavity-type beam position monitors(QBPM, 100nm).

3 Screen Monitors

5 Wire Scanners, Laserwires

Strip-line BPMs

Correctors for feedback



Shintake Monitor (beam size monitor, BSM with laser interferometer)

MONALISA (nanometer alignment monitor with laser interferometer)

Laserwire (beam size monitor with laser beam for 1 μm beam size, 3 axies)

IP intra-train feedback system with latency of less than 150ns (FONT)

Magnet movers for Beam Based Alignment (BBA)

High Available Power Supply (HA-PS) system for magnets

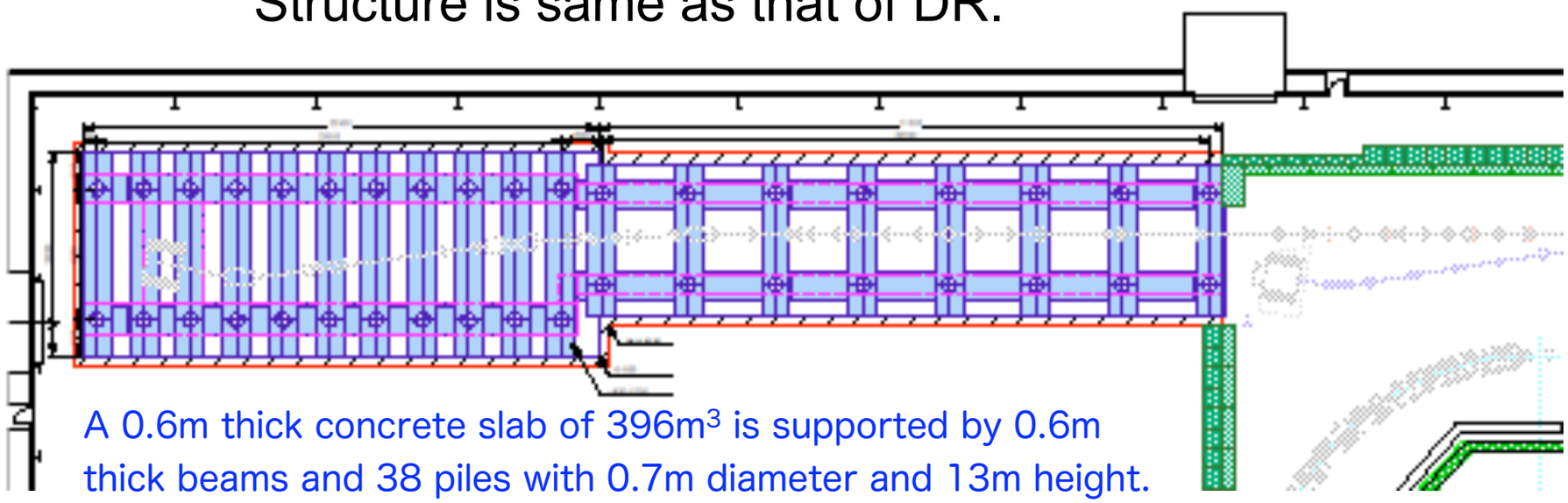
Schedule of Installation, May 2008

Japanese Fiscal year	JFY2007									JFY2008												
	2007									2008												
Activity	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
ATF Beam operation																				ATF2 Commissio					
Reconfiguration of extraction line			partial recons												New ext. line										
Conventional Facilities																									
detailed floor planning	bid						New floor constructed																		
re-location/ site preparation	rab																								
floor refurbishment			Floor																						
construction of extended area							side wall and roof																		
utilities; water, AC power									cable, pipe																
construction at ATF-EXT	partial construction														reconfiguratio										
laser huts for BSM and LW														LW	BSM										
Installation																									
beam dump													DMP												
magnets & supports & vacuum pipes				magne						magne						magnets									
cooling pipes											cooling														
cable tray installation											c. tray						c.tray								
large DC cable installation											power						p.cable								
small cable installation												cables					cables								
power supply system														PS											
new stable FD system with magnets																		FD							
Shintake monitor with IPBPM												shi	BSM												
Laser wire											light path				1 LW , detector										
wire scanners, screen mon. etc.																wire scanr									

Floor structure for ATF2 beam line

Refurbishment from Jun to Sep 2007

Structure is same as that of DR.




29th November 2007


Q-manets installation, 10th January 2008


Beam Dump, 31st March 2008


Shintake mon. optics start, 14th May 2008

cabling and piping, 14th May 2008

HA-PS installation, 14th May 2008

Laser hut construction(LW), 14th May 2008

QBPM phase fine-adjustment, 21st May 2008

Asian Contributions

(1) Optics, beam tuning and commissioning

KEK, IHEP, KNU

(2) Shintake monitor (beam size monitor at IP)

KEK, University of Tokyo

(3) Quadrupole magnets: 28 in total

design (KEK, IHEP, SLAC), production (IHEP),

magnetic field measurement (KEK, IHEP)

(4) Cavity BPMs (QBPMs) with 100nm resolution ; 39 in total

design (KEK, PAL), production (PAL)

digital readout electronics (SLAC)

(5) IPBPM with 2nm resolution ; a IPBPM in BSM and a quartet at IP

design (KEK), production (KEK), electronics (KEK)

lower Q type R&D (KNU)

(6) S-band BPM (at the FD system , i.e. for QD0, SD0, QF1, SF1)

design and production (KNU) in collaboration with RHUL(UK)

American Contributions

- Participation in optics design
- Electronics for Q-BPMs (33 +1)
- Participation in design and measurements of Q-magnets (being made at IHEP)
- Movers for beamline magnets (28)
- High availability power supplies (38)
- Quads for final doublet (2)
- Sextupole magnets (5)
- Final focus bends (3)
- Participation in commissioning and operation

CERN/France Contributions

- Development and implementation of the beam correction algorithms; e.g. GM model
- Beam line modeling with an optimised version of the GEANT4 simulation
- Stabilisation of critical mechanical support structures for the Final Focus magnets
- Development of specific beam instrumentation

DESY Contributions

- Stabilisation study for the FD system and the site (ground motion at the ATF2 floor)
- Laserwire; interest in Compton detector and in data taking + analysis (part of EUROTeV)
- Fast kicker to produce the ILC like bunch structure at ATF2 in the future.
- Remote operations or monitoring (GAN)

UK Contributions

(1) Optics, beam tuning and commissioning

Daresbury lab.

(2) Laserwire

RHUL, Oxford University

(3) Beamline simulation by BDSIM (Geant4)

RHUL

(4) Fast feedback system, FONT and feedforward system

Oxford University, Daresbury lab.

(5) Monalisa ; Compact Straightness Monitor (CMS) at IP

Oxford University

(6) S-band BPM (Design, Electronics system)

RHUL, Oxford University

Component	Sub-component	Number	Comments	Status	Present	New	2007	plan in
Magnet	Quadrupole	28	with QD0,QF1	production	27	1	1	0
	Sextupole	5	4 with 50mm aperture and 2 with 32mm aperture	design	0	5	5	0
	Octupole	0			0	0	0	0
	Bend	3	FF-bends =3	production	0	3	3	0
	H. Steering	4	horizontal with 5A bipolar PS	1 added in v3.7	4	0	0	0
	V. Steering	2	vertical with 5A bipolar PS		2	0	0	0
	Skew Q	2	QK2X, QK3X	v3.7 optics	0	2	0	2
	Cable of ext.kicker	2	re-location of two kickers is alternative solution		0	2	0	2
Magnet Support	Movers	27	20Q-magnets, QD0,QF1 and 5 sextupoles	SLAC	27	0	0	0
	Base (Qs)	23	for each magnet except for the FD support	production	0	23	24	-1
	Bends	3	support system (3 bases and 3 interface plates)	design ?	0	3	3	0
	FD support	1	stable tables for QD0,QF1,SD0,SF1	CERN/LAPP	1	0	0	0
Power Supply	HA system	38	8(ExtQ), 6(MatQ), 5(Sext), 0(Oct), 16(FFQ), 3(B) ; 6 bipolar for QM11FF - QM16FF.	production		38	38	0
	Bipolar PS	2	bipolar and 20A for QK1X, QK2X	v3.7 optics		2	0	2
Vacuum	Beam pipe (m)	93.154	ATF extraction line at present and ATF2 beam line (50.613m)	production	0	93.154	46.577	46.58
BPM	Q-BPM for Q & Sext.	33	QD10-12X,16-17X,QD18-21X, IHEP-Qs in FF	production	39	-6	0	-6
	Q-BPM (s-band)	4	with larger diameter (40mm) ,final doublet system	design	0	4	0	4
	stripline	14	for commissioning and at extraction line	production	14	0	0	0
	IP-BPM	3	2nm resolution for position jitter at IP (	production/prototype	0	3	2	1
Wire scanner	Metal wire	5	exsit at the extraction line - relocation	existing	5	0	0	0
	Laserwire	5	upgrade of the metal wire scanners	R&D	0	5	0	1
IP - BSM	Shintake monitor	1	upgrade of the FFTB monitor, 532nm laser: 35-350nm	upgrade/ new design	1	0	0	0
	BSM-support	1	rigid and independent support	design	0	1	1	0
	Urakawa monitor	1	laser cavity type	R&D	0	1	0	0
Fast orbit correction	Feedforward	1	from DR to extraction line	R&D, design	0	1	1	0
	Feedback	1	intra-train fast feedback based on digital circuit	R&D	0	1	1	0
Pulse to pulse feedback	V and H correctors	4	orbit correction at the extraction line	proposed	0	4	0	4
	1um BPMs	4	orbit correction at the extraction line	proposed	0	4	0	4
Commissioning tools	Screen monitor	4		KEK	4	0	0	0
	Carbon wire scanner	1	beam size monitor at IP : up to 1um	SLAC	1	0	0	0
	Honda monitor	1	beam size monitor at IP : 350nm - 1um	proposed	0	1	0	1
	PLIC loss monitor	1	fiber with PMT readout	proposed	0	1	0	1
ICT	beam loss	2	beam current monitor		1	1	0	1
Beam dump	ATF2 Beam dump	1	design is the same as the ATF one		0	1	1	0

Hardware preparation

(1) 2006

Q magnets (4 in 2006, 24 in 2005, 28 in total); 27 to be used

Support-concrete bases;

type : 1(Q+Qk+ZV),2A(Q+ZH), 2B(Q+ZV),3(Q+Sx+Q) and 4(Q)

no. : 3, 3, 1, 3 and 14 ,respectively ; so 24 in total

QBPMs (28 in 2006, 11 in 2005, 39 in total) - 33 to be used

HA power supply system (39)

(2) 2007-2008

Conventional facility (including beam dump)

Bending(3), sextupole(5), skew(2) and steering(6) magnets

QC3 (2) shimmed for QC0,QF1 - 12 pole component

S-band BPMs (4), IPBPM with New Shintake monitor

Cabon wire scanner, Honda monitor

Rigid supports(FD system, Shintake monitor)

FONT, feedforward, laserwire, Monalisa etc.

Hardware Issues due to budget shortage in JFY2008

The highest priority is to transfer beam to the dump at ATF2.

(1) There are 14 stripline BPMs in total at new extraction line and ATF2. The cables have to be reused from present ones. It is not clear that their lenghts are enough. Some of them may have no cables.

(2) Who provides a PLIC cable system for beam loss monitor at ATF2 ? - Originally, SLAC could do.

(3) There is only one ICT. MC1X will not be available behind QD20X.

(4) There are 4 skew quadrupoles for the coupling correction. At present, only QK1X and QK4X are available together with 20A power supplies. Who provides two remained skew quadrupoles. ?

(5) Honda montor and sweeping magnet is not funded.

(6) Laser tracker system (Raika co.) is close to the lifetime (> 15 years old). It may affect beam line alignment in this summer.
Is it available as rental or who can purchase it ?

Software Issues

Coordination is important for international collaboration.

(1) Commissioning strategy, tools
The commissioning group will provide them.

(2) Flight simulator for modeling the beam line and tuning.
Demonstration was done at the present extraction line.
Preliminary results will be presented here.

(3) Magnet movers and QBPMs etc.
Corresponding sub groups have responsibilities.

(4) Remoto participation
international-capable phone line, good video equipment will be prepared. Also, ATF data server, eLog system will be improved.
Both are KEK's resposibility.

Site work Issues

Scheduling is very important particularly in this summer.

(1) The re-organization and modification of extraction line will be completed by end of July, which includes;

- All the magnets will be aligned.
- After the movement of two extraction kickers, we need to check the HV-system probably in July.

(2) Commissioning of Shintake monitor system with no beam

- High power laser system in restrictive area, - August
- The laser system will move in a laser hut, September.

(4) Installtion of the FD system, September

- Majoy components will be shipped from LAPP to KEK, including the table, 4 magnets and s-band BPMs with supports

ATF2 will be commissioned in early November 2008.

Recent progress and near future plan

(1) Re-configuration will be started in early June.

(2) Concrete shields and beam dump have been completed in April.

(3) All magnets except for 4 FD-ones have been installed at ATF2 beam line.

(4) Power cables and cooling pipes have been installed.

(5) The HA-PS system has arrived at KEK, 1st May.

(6) S band BPMs (4) will be fabricated by end of June at KNU.
The electronics is provided by UK group.

(7) Shintake monitor has been installed at IP. The optics system is setting up and it will be commissioned in May.

(8) FD system will be arrived in early September from LAPP.

Meeting schedule

(1) Weekly meeting, Wednesday

(2) Project meeting, 26-28 May, during Nanobeam 2008, Novosibirsk and Webex.

(3) 6th TB and SGC Joint meeting , 11-12 June

(4) Mini-workshop on the ATF2 flight simulator, 18-20 June,LAL, Webex